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INVESTIGATION OF AERODYNAMIC CHARACTERISTICS OF V-WINGS NEAR SO--ETC(U)
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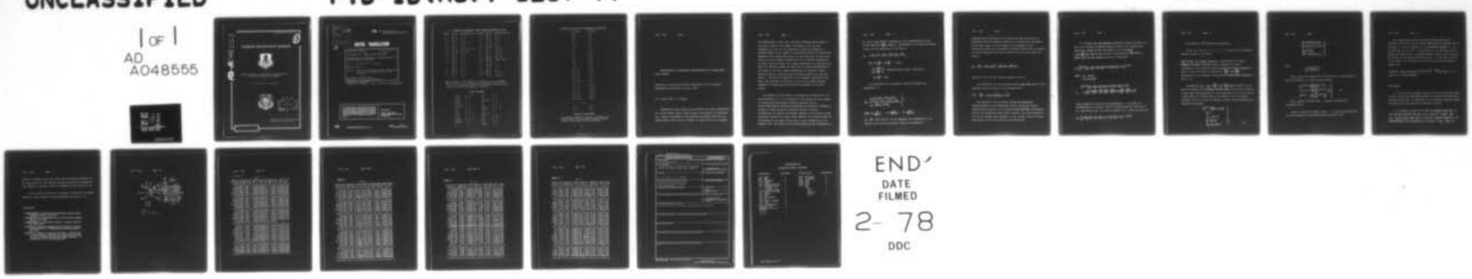

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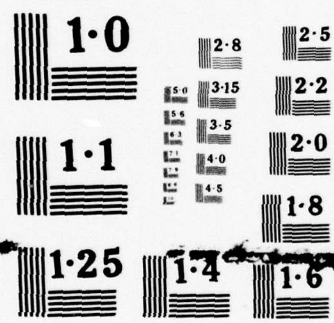

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FOREIGN TECHNOLOGY DIVISION

INVESTIGATION OF AERODYNAMIC CHARACTERISTICS OF V-WINGS NEAR SOLID SURFACE

by

N. B. Plisov, F. F. Latypov

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By: N. B. Plisov, F. F. Latypov

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U. S. BOARD ON GEOGRAPHIC NAMES TRANSLITERATION SYSTEM

Block	Italic	Transliteration	Block	Italic	Transliteration
А а	*А а*	A, a	Р р	*Р р*	R, r
Б б	*Б б*	B, b	С с	*С с*	S, s
В в	*В в*	V, v	Т т	*Т т*	T, t
Г г	*Г г*	G, g	У у	*У у*	U, u
Д д	*Д д*	D, d	Ф ф	*Ф ф*	F, f
Е е	*Е е*	Ye, ye; E, e*	Х х	*Х х*	Kh, kh
Ж ж	*Ж ж*	Zh, zh	Ц ц	*Ц ц*	Ts, ts
З з	*З з*	Z, z	Ч ч	*Ч ч*	Ch, ch
И и	*И и*	I, i	Ш ш	*Ш ш*	Sh, sh
Й й	*Й й*	Y, y	Щ щ	*Щ щ*	Shch, shch
К к	*К к*	K, k	Ъ ъ	*Ъ ъ*	"
Л л	*Л л*	L, l	Ы ы	*Ы ы*	Y, y
М м	*М м*	M, m	Ь ь	*Ь ь*	'
Н н	*Н н*	N, n	Э э	*Э э*	E, e
О о	*О о*	O, o	Ю ю	*Ю ю*	Yu, yu
П п	*П п*	P, p	Я я	*Я я*	Ya, ya

*ye initially, after vowels, and after ъ, ь; e elsewhere. When written as ё in Russian, transliterate as yё or ё. The use of diacritical marks is preferred, but such marks may be omitted when expediency dictates.

GREEK ALPHABET

Alpha	Α α	Nu	Ν ν
Beta	Β β	Xi	Ξ ξ
Gamma	Γ γ	Omicron	Ο ο
Delta	Δ δ	Pi	Π π
Epsilon	Ε ε ϵ	Rho	Ρ ρ ϱ
Zeta	Ζ ζ	Sigma	Σ σ ς
Eta	Η η	Tau	Τ τ
Theta	Θ θ ϑ	Upsilon	Υ υ
Iota	Ι ι	Phi	Φ φ ϕ
Kappa	Κ ϰ κ	Chi	Χ χ
Lambda	Λ λ	Psi	Ψ ψ
Mu	Μ μ	Omega	Ω ω

RUSSIAN AND ENGLISH TRIGONOMETRIC FUNCTIONS

Russian	English
sin	sin
cos	cos
tg	tan
ctg	cot
sec	sec
cosec	csc
sh	sinh
ch	cosh
th	tanh
cth	coth
sch	sech
csch	csch
arc sin	$\sin^{-1}$
arc cos	$\cos^{-1}$
arc tg	$\tan^{-1}$
arc ctg	$\cot^{-1}$
arc sec	$\sec^{-1}$
arc cosec	$\csc^{-1}$
arc sh	$\sinh^{-1}$
arc ch	$\cosh^{-1}$
arc th	$\tanh^{-1}$
arc cth	$\coth^{-1}$
arc sch	sech^{-1}
arc csch	csch^{-1}

---

rot	curl
lg	log

GRAPHICS DISCLAIMER

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INVESTIGATION OF AERODYNAMIC CHARACTERISTICS OF V-WINGS NEAR SOLID SURFACE

(Reported at Scientific-Technical Conference of LKI [Leningrad Ship-Building Institute] in May of 1967)

N. B. Plisov and F. F. Latypov

Determined in this study are the position and rotary derivatives of a V-wing moving above a solid screen. This problem is interesting for a number of problems in the dynamics of vehicles which use the screen effect during motion. Studied is a thin V-wing of rectangular

plan shape above a solid wall. The OXYZ coordinate system bound to the wing is shown in the figure. The planes of the wing are designated as I and II. The direction in which the V-angle is reckoned (shown in the figure) is considered positive. We assume that imposed on the translational motion of the wing along the wall with velocity U_0 are harmonic oscillations of low relative frequency in the pitch and roll planes. The induced velocities are considered low, while the vorticity beyond the wing lies in planes corresponding to the planes of the wing. These assumptions are realized at small angles of attack, relatively great distances between the wing and surface , and when the amplitudes of the harmonic oscillations are small. The condition of equality to zero of the normal velocity component of liquid particles should be satisfied on the solid screen.

The solution to the problem is obtained by the method of S. M. Belotserkovskiy [1, 2, 3]. According to this method the wing surface is replaced by nonstationary discrete vortices, and the integro-differential equations describing the problem are reduced to systems of linear algebraic equations relative to vortex circulations. To satisfy the boundary equation on the screen we must introduce a hypothetical wing, which consists of the mirror image of the boundary of the main wing and has a vortex circulation of the opposite sign. The planes of the mirror-image wing are designated as

III and IV (see figure). According to [1], dimensionaless vortex circulations ($\Gamma_i = \frac{\Gamma_{i\,разм.}}{U_0 \ell_i}$, where ℓ_i - is the span of the horseshoe-shaped vortex) can be represented in the form of:

$$(1) \qquad \Gamma_i = \Gamma_i^{\alpha}\alpha + \Gamma_i^{\dot\alpha}\dot\alpha + \Gamma_i^{\omega_z}\omega_z + \Gamma_i^{\dot\omega_z}\dot\omega_z + \Gamma_i^{\omega_x}\omega_x + \Gamma_i^{\dot\omega_x}\dot\omega_x .$$

Here $\Gamma_i^{\alpha} = \frac{\partial \Gamma_i}{\partial \alpha}$; $\Gamma_i^{\dot\alpha} = \frac{\partial \Gamma_i}{\partial \dot\alpha}$ ... etc.;

$$\left.\begin{aligned} \omega_z &= \frac{\Omega_{z} \cdot b}{U_0} \\ \omega_x &= \frac{\Omega_{x} \cdot b}{U_0} \end{aligned}\right\} \text{ - dimensionaless angular velocities;}$$

$$\dot\alpha = \frac{d\alpha}{dt} \quad \text{etc.}$$

The coefficients of aerodynamic forces and moments are determined [1]

$$(2) \qquad \left.\begin{aligned} C_y &= C_y^{\alpha}\alpha + C_y^{\dot\alpha}\dot\alpha + C_y^{\omega_z}\omega_z + C_y^{\dot\omega_z}\dot\omega_z \\ m_z &= m_z^{\alpha}\alpha + m_z^{\dot\alpha}\dot\alpha + m_z^{\omega_z}\omega_z + m_z^{\dot\omega_z}\omega_z \\ m_x &= m_x^{\omega_x}\omega_x + m^{\dot\omega_x}\dot\omega_x \end{aligned}\right\},$$

where $C_y = \frac{Y}{\frac{\rho U_0^2}{2} \cdot \ell \cdot b}$; $\quad m_z = \frac{M_z}{\frac{\rho U_0^2}{2} \cdot \ell \cdot b^2}$; $\quad m_x = \frac{M_x}{\frac{\rho U_0^2}{2} \cdot \ell \cdot b^2}$;

C_y^{α}; $C_y^{\omega_z}$; $C_y^{\dot\omega_z}$; m_z^{α} etc. in (2) represent the coefficient of the position and rotary derivatives. These are expressed as

dimensionaless circulations of attached vortices. The latter are determined from the boundary condition of non-flow over the surface of the wing, which, on the strength of the symmetry of the longitudinal axes can be satisfied at discrete points only on surface I. In the linearized form this condition for the V-wing takes the form of:

$$\frac{W_n}{U_0} = -\alpha\cos\beta + \left(\omega_z\frac{x_0}{b} - \omega_x\frac{z_0}{b}\right)\cos\beta - \omega_x\frac{y_0}{b}\sin\beta, \tag{3}$$

where $W_{\bar{n}}$ is the induced velocity normal to plane I.

By introducing the new coordinate system $O\xi\eta\zeta$ (see figure), this condition can be written in the following form:

$$\frac{W_n}{U_0} = -\alpha\cos\beta + \omega_z\frac{\xi_0}{b}\cos\beta - \omega_x\frac{\zeta_0}{b}. \tag{3'}$$

The solution to the analogous problem for determining characteristics in the longitudinal plane ($\omega_x = 0$) for certain complex lifting systems in an unlimited fluid has been investigated in [4]. The expressions below differ somewhat from those obtained in [4] for the studied case. Moreover, in the present study the rotary derivatives in the roll plane are also determined.

If we assume that the kinematic parameters change according to a law in the form of $\alpha = \alpha_0 \sin pt$, and we introduce the dimensionless velocities induced by the i-th vortex at the j-th point ($w_{ij} = \frac{2\pi}{U_0 \Gamma_i} W_{ij}$), then at low relative frequencies ($q = \frac{pb}{U_0} = 0$) we can obtain from (3) the following system of equations:

$$(4)\quad \sum_{i=1}^{m} \Gamma_i^{\alpha,\omega_z}\left[w^{I}_{\eta ij} - w^{II}_{\eta ij} + (w^{II}_{\eta ij} - w^{III}_{\eta ij})\cos 2\beta + (w^{II}_{\zeta ij} - w^{III}_{\zeta ij})\sin 2\beta\right] = f^{\alpha,\omega_z},$$

where
$$f^{\alpha} = -2\pi\cos\beta;$$
$$f^{\omega_z} = 2\pi\cos\beta\,\frac{\xi_{oj}}{b};$$

$$(5)\quad \sum^{m} \Gamma_i^{\dot\alpha,\dot\omega_z}\left[w^{I}_{\eta ij} - w^{II}_{\eta ij} + (w^{II}_{\eta ij} - w^{III}_{\eta ij})\cos 2\beta + (w^{II}_{\zeta ij} - w^{III}_{\zeta ij})\sin 2\beta\right] = -\frac{\lambda}{4N}\sum_{i=1}^{m}\Gamma_i^{\alpha,\omega_z}\left[\frac{\partial w^{I}_{\eta ij}}{\partial q} - \frac{\partial w^{II}_{\eta ij}}{\partial q} + \left(\frac{\partial w^{II}_{\eta ij}}{\partial q} - \frac{\partial w^{III}_{\eta ij}}{\partial q}\right)\cos 2\beta + \left(\frac{\partial w^{II}_{\zeta ij}}{\partial q} - \frac{\partial w^{III}_{\zeta ij}}{\partial q}\right)\sin 2\beta\right],$$

where $\lambda = \frac{l}{b}$ is the aspect ratio of the wing; N - the number of vortices for the half-span. Load Γ^{ω_x} is antisymmetical relative to the longitudinal axes, and thus the system for it takes the form of:

$$(6)\quad \sum_{i=1}^{m} \Gamma_i^{\omega_x}\left[w^{I}_{\eta ij} + w^{II}_{\eta ij} + (-w^{II}_{\eta ij} - w^{III}_{\eta ij})\cos 2\beta + (-w^{II}_{\zeta ij} - w^{III}_{\zeta ij})\sin 2\beta\right] = -2\pi\,\frac{\zeta_0}{b}.$$

The system for $\Gamma_i^{\dot{\omega}_x}$ is written analogously.

In (4), (5), and (6) j = 1, 2, 3 ... m, where m is the number of vortices on half of the wing:

$w_{\eta ij}^{M}$ and $w_{\zeta ij}^{M}$ (M = I,II,III,IV) represent, respectively, the normal component of plane M and the parallel component of plane M (transverse) of the velocity induced by the i-th vortex belonging to plane M at the j-th point on surface I; $\frac{\partial w_{\eta ij}^{M}}{\partial q}$ and $\frac{\partial w_{\zeta ij}^{M}}{\partial q}$ - derivatives of the indicated velocities for dimensionless frequency q when q = 0.

Formulas for $w_{\eta ij}$; $w_{\zeta ij}$; $\frac{\partial w_{\eta ij}}{\partial q}$ and $\frac{\partial w_{\zeta ij}}{\partial q}$ were obtained in [2]. They are written in a coordinate system bound to the vortex, and thus we must know the expressions for the coordinates of the j-th point on I which refer to the half-span of the vortex in all the systems related to the i-th vortex on different planes. These expressions are provided by formulas:

$$\left.\begin{aligned} \xi_{ij}^{I,II,III,IV} &= \frac{4N}{\pi\lambda}\left(\frac{1}{2}-\mu_i+\nu_j\right) \\ \eta_{ij}^{I} &= 0 \\ \zeta_{ij}^{I} &= -2(K_i-K_j) \\ \eta_{ij}^{II} &= A_j \sin 2\beta \\ \zeta_{ij}^{II} &= -A_j \cos 2\beta - A_i \end{aligned}\right\}. \quad (7)$$

$$\left.\begin{aligned}
\eta_{ij}^{\mathrm{I}} &= 8N\bar{h}\cos\beta + A_j\sin 2\beta\\
\zeta_{ij}^{\mathrm{I}} &= 8N\bar{h}\sin\beta - A_j\cos 2\beta + A_i\\
\eta_{ij}^{\mathrm{II}} &= 8N\bar{h}\cos\beta\\
\zeta_{ij}^{\mathrm{II}} &= -8N\bar{h}\sin\beta - A_j - A_i
\end{aligned}\right]$$

where

$$A_j = 2N-(2k_j-1);$$
$$A_i = 2N-(2k_i-1).$$

After solving the systems for circulations, the coefficients of rotary derivatives are found through formulas

$$\left.\begin{aligned}
c_y^{\alpha,\dot{\alpha},\omega_z,\dot{\omega}_z} &= \frac{\lambda\cos\beta}{N^2}\sum_{i=1}^{m}\Gamma_i^{\alpha,\dot{\alpha},\omega_z,\dot{\omega}_z}\\
m_z^{\alpha,\dot{\alpha},\omega_z,\dot{\omega}_z} &= \frac{\lambda\cos\beta}{N^2}\sum_{i=1}^{m}\Gamma^{\alpha,\dot{\alpha},\omega_z,\dot{\omega}_z}\frac{\xi_i}{b}\\
m_x^{\omega_x,\dot{\omega}_x} &= -\frac{\lambda}{2N^2}\sum_{i=1}^{m}\Gamma_i^{\omega_x,\dot{\omega}_x}\frac{\zeta_i}{l/2}
\end{aligned}\right\}. \qquad (8)$$

For a negative dihedral wing - β should be substituted everywhere for β.

Series of wings with aspect ratios λ = 1-4 were calculated from the above formulas on high-speed digital computer M-20.

The V-angles were varied from zero to $\pm 45°$; the relative distance of the wings from the screen was $\bar{h} = 0,1 \div \infty$. A system with 40 vortices (m = 40) was selected as the calculation system: 8 - over the half-span (N = 8) and 5 - over chord (n = 5). The work of the machine was monitored by a manually checked control variation and by the values of the rotary derivatives when $\beta = 0$, the data on which can be found in [3]. Results of the calculations are presented in Tables 1-4*.

[FOOTNOTE: Characteristics c_y^{α}; $c_y^{\omega_z}$; m_z^{α}; $m_z^{\omega_z}$ $m_x^{\omega_x}$ for wing of $\lambda = 3$ given in [5]. END FOOTNOTE.]

CONCLUSIONS

1. At the selected constant values of $\bar{h}$ for all wing span ratios we see a significant dependence between the studied characteristics and the V-angle. This is explained by the different distances between the screen and wing sections at different β values.

2. In comparing positive and negative dihedral wings for the same minimal distance from the screen (when $\beta \geq 0$ $\bar{h}_{min} = \bar{h}$; when $\beta < 0$ $\bar{h}_{min} = \bar{h} - \frac{1}{2}\sin\beta$) wings with the negative dihedral (anhedral) have characteristics and derivatives with respect to $\bar{h}_{min}$ which are

greater in absolute value than wings with the positive dihedral for the same value of β. The maximal characteristics and $\bar{h}$ derivatives with respect to absolute value are possessed by flat wings ($\beta = 0$).

3. For V-wings the shift in the pressure center when the height above the screen changes is less significant than when $\beta = 0$.

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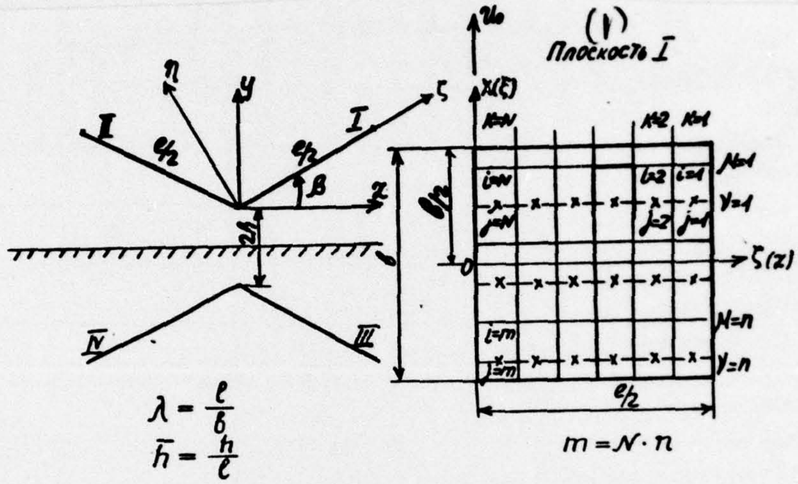

Fig. 1.

Key: (1) Plane I.

Table 1.

$\lambda = I$

$\bar{h}$	β°	c_y^{α}	$c_y^{\omega_z} = m_z^{\alpha}$	$m_z^{\omega_z}$	$m_x^{\omega_x}$	$c_y^{\dot{\alpha}}$	$c_y^{\dot{\omega}_z} = m_z^{\dot{\alpha}}$	$m_z^{\dot{\omega}_z}$	$m_x^{\dot{\omega}_x}$
$\bar{h} = 0,I$	0	3,065	0,867	-0,I9I	-0,0775	I,5I7	-0,0I76	-0,047I	-0,058I
	I0	2,307	0,683	-0,I65	-0,0682	I,227	-0,0I20	-0,04I5	-0,05II
	20	I,86I	0,565	-0,I42	-0,0640	I,I02	-0,0086	-0,0364	-0,0479
	30	I,498	0,462	-0,II9	-0,06I3	0,842	-0,0066	-0,0308	-0,0457
	45	I,006	0,3I5	-0,084	-0,0580	0,580	-0,005I	-0,02I3	-0,0430
$\bar{h} = 0,I5$	0	2,465	0,7I4	-0,I62	-0,0668	I,238	-0,0063	-0,043I	-0,0507
	I0	2,057	0,6I7	-0,I49	-0,06I7	I,09I	-0,0054	-0,0400	-0,0477
	-I0	3,329	0,903	-0,I75	-0,0779	I,456	-0,0022	-0,0492	-0,0588
	20	I,736	0,53I	-0,I33	-0,0605	0,949	-0,0046	-0,0357	-0,0459
	30	I,432	0,444	-0,II4	-0,0587	0,800	-0,004I	-0,0300	-0,0444
	45	0,983	0,308	-0,082	-0,0562	0,564	-0,0039	-0,02I3	-0,0422
$\bar{h} = 0,3$	0	I,886	0,577	-0,I38	-0,0577	0,988	-0,0034	-0,04I0	-0,0449
	I0	I,745	0,542	-0,I34	-0,057I	0,938	-0,0024	-0,0392	-0,0443
	-I0	I,990	0,595	-0,I37	-0,0585	I,002	-0,0046	-0,0409	-0,0455
	20	I,558	0,488	-0,I24	-0,0565	0,855	-0,00I3	-0,0357	-0,0437
	-20	2,096	0,606	-0,I28	-0,0602	0,985	-0,0074	-0,0398	-0,0465
	30	I,33I	0,420	-0,I08	-0,0557	0,743	-0,0008	-0,0307	-0,0430
	45	0,944	0,299	-0,080	-0,0540	0,540	-0,0002		
$\bar{h} = 0,5$	0	I,56	0,506	-0,I34	-0,0549	0,860	-0,0I26	-0,0427	-0,0434
	I0	I,52	0,493	-0,I3I	-0,0548	0,839	-0,0II7	-0,04I4	-0,0433
	-I0	I,52	0,495	-0,I3I	-0,0548	0,840	-0,0II8	-0,04I5	-0,0433
	20	I,40	0,457	-0,I22	-0,0545	0,782	-0,0095	-0,0378	-0,0430
	-20	I,42	0,459	-0,I22	-0,0545	0,785	-0,0097	-0,0379	-0,0430
	30	I,I2	0,400	-0,I07	-0,0539	0,693	-0,0063	-0,0324	-0,0425
	-30	I,25	0,404	-0,I07	-0,0540	0,696	-0,0066	-0,0326	-0,0425
	45	0,903	0,29I	-0,0786	-0,0526	0,5I6	-0,00I5	-0,0224	-0,04I2
	-45	0,920	0,295	-0,0786	-0,0527	0,520	-0,00I7	-0,0226	-0,04I3
$\bar{h} = \infty$	0	I,543	0,504	-0,I34	-0,0548	0,854	-0,0I30	-0,0429	-0,0433
	I0	I,506	0,49I	-0,I3I	-0,0547	0,835	-0,0I22	-0,04I6	-0,0433
	20	I,398	0,455	-0,I22	-0,0544	0,779	-0,0I00	-0,0380	-0,0430
	30	I,230	0,399	-0,I07	-0,0538	0,690	-0,0067	-0,0325	-0,0425
	45	0,900	0,290	-0,079	-0,0525	0,5I4	-0,00I7	-0,0224	-0,04I2

Table 2.

$\lambda = 2$

$\bar{h}$	β	c_y^{α}	$c_y^{\omega_z}=m_z^{\alpha}$	$m_z^{\omega_z}$	$m_x^{\omega_x}$	$c_y^{\dot{\alpha}}$	$c_y^{\dot{\omega}_z}=m_z^{\dot{\alpha}}$	$m_z^{\dot{\omega}_z}$	$m_x^{\dot{\omega}_x}$
$\bar{h}$ = 0,I	0	4,507	I,I09	-0,I25	-0,585	0,958	-0,I29	-0,0777	-0,336
	I0	3,575	0,922	-0,I22	-0,5I5	0,942	-0,0938	-0,067I	-0,300
	20	2,956	0,783	-0,II3	-0,483	0,853	-0,0757	-0,0588	-0,282
	30	2,4I2	0,649	-0,0977	-0,463	0,733	-0,060I	-0,0492	-0,268
	45	I,64I	0,443	-0,0689	-0,440	0,525	-0,0365	-0,0327	-0,252
$\bar{h}$ = 0,I5	0	3,725	0,959	-0,II8	-0,507	0,843	-0,I24	-0,0755	-0,302
	I0	3,2I9	0,855	-0,II8	-0,476	0,850	-0,0996	-0,0682	-0,286
	-I0	4,633	I,I29	-0,I08	-0,59I	0,656	-0,I89	-0,0900	-0,343
	20	2,770	0,749	-0,II0	-0,460	0,79I	-0,0820	-0,0603	-0,275
	30	2,3I3	0,63I	-0,096I	-0,447	0,694	-0,0650	-0,0504	-0,266
	45	I,604	0,436	-0,0683	-0,429	0,508	-0,0390	-0,0333	-0,252
$\bar{h}$ = 0,3	0	2,992	0,823	-0,II8	-0,442	0,757	-0,II9	-0,0750	-0,279
	I0	2,8I0	0,78I	-0,II7	-0,438	0,76I	-0,I06	-0,0707	-0,275
	-I0	3,088	0,836	-0,II2	-0,449	0,699	-0,I30	-0,0764	-0,282
	20	2,533	0,707	-0,II0	-0,433	0,72I	-0,09I	-0,063I	-0,270
	-20	3,I35	0,825	-0,0972	-0,462	0,570	-0,I46	-0,0770	-0,286
	30	2,I80	0,607	-0,0957	-0,428	0,644	-0,0725	-0,0527	-0,264
	45	I,552	0,427	-0,068I	-0,4I6	0,484	-0,043I	-0,0345	-0,253
$\bar{h}$ = 0,5	0	2,756	0,779	-0,I2I	-0,428	0,737	-0,II8	-0,0757	-0,275
	I0	2,654	0,752	-0,I20	-0,427	0,733	-0,II0	-0,0722	-0,273
	-I0	2,732	0,768	-0,II7	-0,427	0,704	0,I20	-0,0746	-0,275
	20	2,435	0,689	-0,III	-0,425	0,694	-0,0954	-0,0647	-0,270
	-20	2,580	0,720	-0,I06	-0,426	0,638	-0,II4	-0,0693	-0,273
	30	2,I20	0,596	-0,0965	-0,42I	0,623	-0,0766	-0,054I	-0,265
	-30	2,324	0,639	-0,0898	-0,423	0,546	-0,I02	-0,0604	-0,268
	45	I,528	0,423	-0,0684	-0,4I0	0,472	-0,0456	-0,0353	-0,254
	-45	I,777	0,474	-0,0608	-0,4I8	0,379	-0,0757	0,0427	-0,257
$\bar{h}$ = ∞	0	2,600	0,746	-0,I28	-0,424	0,728	-0,II8	-0,0763	-0,275
	I0	2,535	0,727	-0,I24	-0,423	0,7I3	-0,II4	-0,0737	-0,274
	20	2,350	0,67I	-0,II4	-0,42I	0,670	-0,I0I	-0,0665	-0,272
	30	2,063	0,584	-0,0986	-0,4I7	0,60I	-0,08I8	-0,0557	-0,269
	45	I,504	0,4I8	-0,0693	-0,406	0,459	-0,0489	-0,0363	-0,260

Table 3.

$\lambda - 3$

$\bar{h}$	$\beta°$	C_y^{α}	$C_y^{\omega_z} = m_z^{\alpha}$	$m_z^{\omega_z}$	$m_x^{\omega_x}$	$C_y^{\dot{\alpha}}$	$C_y^{\dot{\omega}_z} = m_z^{\dot{\alpha}_z}$	$m_z^{\dot{\omega}_z}$	$m_x^{\dot{\omega}_x}$
$\bar{h} = 0{,}1$	0	5,044	I,2I	-0,088I	-I,789	0,I34	-0,3I4	-0,II9	-0,788
	I0	4,I75	I,050	-0,0932	-I,588	0,3I9	-0,249	-0,I04	-0,7I5
	20	3,530	0,907	-0,089I	-I,50	0,356	-0,208	-0,09I7	-0,674
	30	2,9I5	0,756	-0,0784	-I,45	0,338	-0,I68	-0,0765	-0,640
	45	I,99	0,5I6	-0,0550	-I,38	0,264	-0,I07	-0,0502	-0,594
$\bar{h} = 0{,}15$	0	4,3I	I,09	-0,090I	-I,57	0,I52	-0,298	-0,II8	-0,738
	I0	3,83	0,99I	-0,0939	-I,485	0,278	-0,253	-0,I07	-0,703
	-I0	5,068	I,22	-0,0746	-I,8I	-0,238	-0,39I	-0,I36	-0,8I2
	20	3,35	0,877	-0,0894	-I,44	0,3I5	-0,2I5	-0,0944	-0,676
	30	2,82	0,74I	-0,0785	-I,40	0,307	-0,I75	-0,0786	-0,650
	45	I,95	0,5I0	-0,0550	-I,36	0,248	-0,II0	-0,05I2	-0,607
$\bar{h} = 0{,}3$	0	3,64	0,972	-0,0983	-I,40	0,I87	-0,284	-0,II8	-0,7II
	I0	3,46	0,926	-0,0986	-I,384	0,243	-0,260	-0,III	-0,700
	-I0	3,7I	0,976	-0,0906	-I,4I	0,0877	-0,30I	-0,I20	-0,7I6
	20	3,I3	0,839	-0,0922	-I,37	0,267	-0,226	-0,0986	-0,684
	-20	3,66	0,946	-0,0756	-I,45	-0,08I8	-0,3I8	-0,I20	-0,7I8
	30	2,69	0,720	-0,080I	-I,36	0,265	-0,I84	-0,0 I9	-0,664
	45	I,9I	0,502	-0,0556	-I,32	0,225	-0,II6	-0,0529	-0,627
$\bar{h} = 0{,}5$	0	3,43	0,93I	-0,I04	-I,36	0,206	-0,279	-0,II8	-0,7I2
	I0	3,32	0,899	-0,I03	-I,356	0,236	-0,262	-0,II3	-0,705
	-I0	3,39	0,9I5	-0,099	-I,36	0,I69	-0,280	-0,II7	-0,7I2
	20	3,043	0,822	-0,0946	-I,35I	0,248	-0,23I	-0,I00	-0,692
	-20	3,I8	0,852	-0,0887	-I,353	0,I24	-0,264	-0,I09	-0,704
	30	2,64	0,7I0	-0,08I6	-I,340	0,246	-0,I90	-0,0835	-0,675
	-30	2,83	0,750	-0,0736	-I,350	0,076	-0,235	-0,0947	-0,688
	45	I,89	0,498	-0,0562	-I,3I	0,2I4	-0,II9	-0,0538	-0,64I
	-45	2,II	0,545	-0,0473	-I,33	0,0I29	-0,I7I	-0,0665	-0,644
$\bar{h} = \infty$	0	3,29	0,898	-0,III	-I,35	0,236	-0,272	-0,II7	-0,7I7
	I0	3,2I	0,874	-0,I08	-I,345	0,236	-0,262	-0,II3	-0,7I5
	20	2,96	0,805	-0,098	-I,34	0,235	-0,235	-0,I02	-0,708
	30	2,59	0,698	-0,0840	-I,33	0,228	-0,I95	-0,085I	-0,697
	45	I,87	0,494	-0,0572	-I,3I	0,200	-0,I23	-0,0548	-0,672

Table 4.

$\lambda = 4$

$\bar{h}$	β^{o}	C_y^{α}	$C_y^{\omega_z}=m_z^{\alpha}$	$m_z^{\omega_z}$	$m_x^{\omega_x}$	$C_y^{\dot{\alpha}}$	$C_y^{\dot{\omega}_z}=m_z^{\dot{\alpha}}$	$m_z^{\dot{\omega}_z}$	$m_x^{\dot{\omega}_x}$
$\bar{h}$ = 0,I	0	5,273	I,277	-0,0673	-3,809	-0,56I	-0,475	00,I58	-I,256
	I0	4,505	I,I29	-0,0749	-3,425	-0,290	-0,400	-0,I42	-I,I60
	20	3,874	0,987	-0,0733	-3,266	-0,I70	-0,342	-0,I25	-I,09I
	30	3,226	0,827	-0,0650	-3,I72	-0,0992	-0,28I	-0,I04	-I,027
	45	2,208	C,563	-0,0452	-3,055	-0,0308	-0,I82	-0,0684	-0,939
$\bar{h}$ = 0,I5	0	4,644	I,I70	-0,0724	-3,396	-0,502	-0,462	-0,I59	-I,227
	I0	4,207	I,079	-0,0775	-3,237	-0,3I6	-0,408	-0,I46	-I,I77
	-I0	5,250	I,274	-0,0562	-3,878	-0,948	-0,560	-0,I77	-I,306
	20	3,7I5	0,96I	-0,0747	-3,I54	-0,207	-0,352	-0,I29	-I,I25
	30	3,I4I	0,8I3	-0,0657	-3,095	-0,I30	-0,290	-0,I07	-I,070
	45	2,I78	0,558	-0,0454	- 3,004	-0,047I	-0,I86	-0,0697	-0,978
$\bar{h}$ = 0,3	0	4,082	I,070	-0,083I	-3,073	-0,440	-0,452	-0,I6I	-I,242
	I0	3,889	I,023	-0,0839	-3,05I	-0,344	-0,4I8	-0,I5I	-I,2I8
	-I0	4,I06	I,068	-0,0756	-3,I06	-0,552	-0,470	-0,I63	-I,248
	20	3,53I	0,928	-0,0784	-3,029	-0,257	-0,367	-0,I34	-I,I82
	-20	3,992	I,023	-0,06I5	-3,I80	-0,7I2	-0,480	-0,I605	-I,232
	30	3,037	0,795	-0,0679	-3,003	-0,I76	-0,302	-0,II2	-I,I34
	45	2,I38	0,55I	-0,0462	-2,940	-0,0725	-0,I93	-0,07I7	-I,050
$\bar{h}$ = 0,5	0	3,900	I,033	-0,0894	-3,00	-0,405	-0,445	-0,I6I	-I,264
	I0	3,770	0,999	-0,0880	-3,00	-0,349	-0,42I	-0,I53	-I,247
	-I0	3,835	I,0I4	-0,0848	-3,00	-0,440	-0,444	-0,I59	-I,265
	20	3,456	0,9I3	-0,08II	-2,98	-0,276	-0,373	-0,I37	-I,2I5
	-20	3,580	0,94I	-0,075I	-2,99	-0,448	-0,4I7	-0,I47	-I,246
	30	2,992	0,786	-0,0694	-2,97	-0,I97	-0,308	-0,II3	-I,I73
	-30	3,I59	0,823	-0,06I5	-2,98	-0,429	-0,368	-0,I28	-I,205
	45	2,I2I	0,547	-0,0468	-2,9I3	-0,0857	-0,I96	-0,0727	-I,094
	-45	2,3I5	0,590	-0,038I	-2,952	-0,352	-0,263	-0,0890	-I,092
$\bar{h}$ = ∞	0	3,766	I,003	-0,0962	-2,98	-0,355	-0,434	-0,I58	-I,284
	I0	3,668	0,975	-0,0932	-2,98	-0,337	-0,4I9	-0,I53	-I,279
	20	3,385	0,897	-0,0847	-2,97	-0,286	-0,377	-0,I38	-I,265
	30	2,946	0,775	-0,07I8	-2,95	-0,2I5	-0,3I3	-0,II5	-I,24I
	45	2,I0I	0,543	-0,0478	-0,0289	-0,I00	-0,200	-0,0738	-I,I87

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